

Introduction

Iran has a dry climate with diverse microclimates and uneven rainfall. Agricultural production relies heavily on irrigation systems, especially during dry seasons. Definitions of conservation agriculture vary worldwide, and no unified operational standard exists yet.

Key Concepts in Conservation Agriculture

- Focuses on no-till or reduced tillage, soil cover, and crop rotation.
- Implementation success depends heavily on local climate, soil, and water conditions.
- Cornell University's semi-permanent vegetation approach is promising but underutilized globally.

Long-Term Implementation Challenges

- Nutrient layering: topsoil becomes enriched while deeper layers are depleted.
- Organic matter concentrates in surface layers, affecting biodiversity.
- Soil compaction due to machinery and lack of residue incorporation.
- Weed resistance, rodent outbreaks, and dependence on fertilizers and specialized equipment.
- Poor root distribution and nitrogen accumulation near the soil surface.

Challenges in Direct Seeding in Irrigated Alborz Fields

- Accumulation of residues, weed dominance, and cold moist soil delaying germination.
- Uneven residue distribution and field leveling loss.
- Rodent increase interfering with irrigation.
- Phosphorus and potassium layering and herbicide dependency.

Performance Comparison: Conventional vs. Conservation Management

- Over 10 years, conservation methods resulted in slightly lower average wheat yield.
- However, under drought stress and specific rotations, conservation farming outperformed.

- Crop diversity and residue management are key factors for success.

Experimental Results and Economic Analysis

- Optimal seed density: 600 seeds/m² with the Sivand wheat variety.
- Highest benefit-cost ratio of 2.71 and net present value around 60.2 million IRR.
- Conservation agriculture reduced dependency on inputs and environmental impact.

Green Manure and Cover Crops

- Crucial for improving soil fertility and boosting carbon levels, especially in low-carbon soils.
- Recommended rotations: Summer fallow → Green manure → Irrigated wheat.
- Cover crops like sorghum-sudangrass, forage millet, vetch, and clover are effective for:
 - Boosting soil organic carbon
 - Weed suppression
 - Enhancing root zones and cation exchange

Water Use Efficiency and Yield Improvements

- Wheat yield reached up to 8489 kg/ha after four years.
- Water required per kilogram of grain decreased from 0.77 to 0.61 m³.
- Up to 50–60% irrigation savings achieved through improved soil structure.

Environmental and Agronomic Benefits

- Enhanced soil health, nutrient availability, biodiversity, and water retention.
- Increased resilience against stress, reduced erosion, and more efficient land use.
- Long-term adoption leads to sustainable and fertile agricultural systems.

Final Recommendations

- Do not burn crop residues—keep at least 30% in the soil surface and incorporate the remaining crop residues to the soil.

- Promote long-term, diverse crop rotations including green manure systems.
- Avoid and discard moldboard plowing; Use light weight disc harrows only to support conservation strategies.
- Employ mechanical weed management and reduce herbicide reliance.